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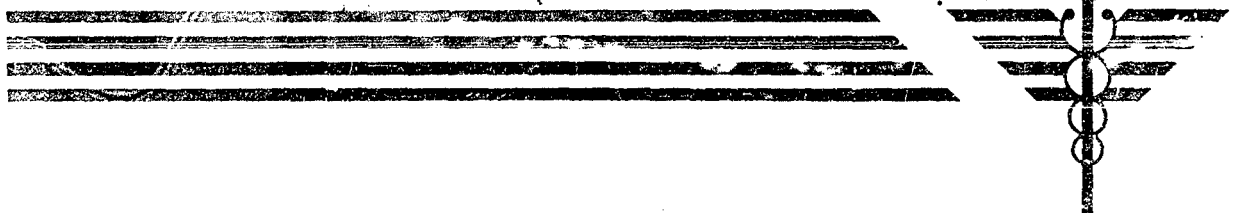
ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

PROJECT NO. 1 - Cold Weather Operations

Sub-Project No. 1-1, Test of the Adequacy and Range of Use of Winter Clothing; and Sub-Project No. 1-18, Study of the Methods for Selection of Personnel for Cold Weather Operations.

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RESEARCH AND DEVELOPMENT DIVISION
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

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ARMORED MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 1-1, 1-18
727-1 SPMEA

10 April 1944

1. PROJECT: No. 1, Cold Weather Operations, Sub-Project No. 1-1, Test of the Adequacy and Range of Use of Winter Clothing; and Sub-Project No. 1-18, Study of the Methods for Selection of Men for Cold Weather Operations.

a. Authority: Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, File 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose: To study the differences in the responses of men to cold; and to attempt to identify the individual attributes - anatomic, physiologic and psychologic - which may be responsible for variation in the perception of distressing symptoms resulting from exposure to cold.

2. DISCUSSION:

a. It is the general practice to evaluate the protection afforded by cold weather clothing in terms of skin temperatures, of insulation expressed as "clo" value, and of changes in the comfort status of the subjects. Major emphasis in the evaluation of clothing has been placed upon the length of time it has been possible for a subject to remain seated in the cold in reasonable comfort.

b. In laboratory studies, the loss of body heat or drop in temperature of local areas in well-clothed healthy men has not been demonstrated to be of sufficient magnitude to be harmful. Changes in the temperature of the toes, where the greatest changes take place, have but rarely been associated with even suggestion of tissue injury. Moreover, changes in body temperature have never been large, nor have they appeared to bear a consistent relationship to the amount of clothing worn. It seems therefore that the clothing of the healthy man is properly evaluated on a comfort basis, using subjective responses as the criteria. For wounded and injured men on the other hand, the requirements with regard to thermal protection have yet to be ascertained.

c. Conclusions with regard to comfort value of clothing however, have been drawn in terms of an "average" soldier, never identified, but tacitly assumed to exist. Yet it has become increasingly apparent that there are major differences among men in their relative capacities to remain comfortable in the cold. Accordingly, this study was undertaken for the purpose of surveying the extent to which military personnel dressed in arctic clothing varies in its tendency to experience distressing symptoms upon inactive exposure to ambient temperatures of -10°F to -14°F.

d. The conditions of test have been selected to impose the greatest stress on the subject. To this end, the subjects have been seated quietly in the cold room, with no opportunity to gain any advantage from exercise in the form of increased heat production, peripheral arteriolar and capillary dilatation both in muscle and skin, and heat produced by friction between the feet and footgear, or the psychological advantage of distraction, all of which can materially improve man's comfort status.

3. CONCLUSIONS:

a. The variations in the sensory experiences of men exposed to cold are significant. Men may be classified into three relative categories of response: resistant, susceptible, and intermediate. This is true for colored as well as for white troops.

b. The rectal and skin temperature changes of these men do not correspond well with their sensory experiences.

c. No one attribute nor any group of attributes - anatomic, physiologic, or psychologic - has been identified which would make possible the prediction of an inactive individual's capacity to remain comfortable in the cold.

4. RECOMMENDATIONS:

No specific recommendations are made. Attention is called to the need in clothing testing for proper pairing of subjects in accordance with their sensory reactions to cold. The need for further study of the stimuli which affect the sensory experience of cold is also indicated.

Prepared by:

Arthur Freedman, Captain, MC
Steven M. Horvath, Captain, SnC

APPROVED

Willard Machle
WILLARD MACHLE
Colonel, Medical Corps
Commanding

4 Incls.

- #1 - Appendix 1, Survey of Sensory Experience of Subjects Exposed to Cold
- #2 - Appendix 2, Comparison of Temperature Data on These Subjects with their Sensory Experience
- #3 - Appendix 3, Study of a Number of Attributes of the Subjects with a View to Identifying some which might be Related to Comfort in the Cold
- #4 - Charts, 1 thru 11

APPENDIX 1

SURVEY OF SENSORY EXPERIENCE OF SUBJECTS EXPOSED TO COLD.

a. Discussion.

The wide range of behavior characteristics toward cold among men should be taken into account in evaluating the protective value of cold weather clothing. Any assertion that a set of garments offers protection down to a certain temperature may be quite misleading without such consideration. It is perfectly proper to raise the question - "For which man - resistant or susceptible - is a given outfit protective?"

Because a method of classifying subjects in terms of resistance to cold was believed to be fundamental to cold room procedures, a survey of a representative sample of men was undertaken. Seventy-five (75) men including 56 white and 19 colored, were examined in eight (8) groups of approximately ten (10) men each. All men were regular Fort Knox troops who had had at least several months army experience beyond their basic training.

Each group was tested for three (3) days, a new group arriving at the laboratory on successive Monday and Thursday mornings. All were exposed in the cold room for the same length of time, and at the same time of the day. Since the purpose of the test was primarily to observe differences in relative resistance to cold, all subjects wore the same arctic clothing outfit, as carefully fitted as possible. When accurate fit was impossible, the subject was given a larger garment rather than a smaller one. By and large, the smaller men had somewhat oversize clothing, while the other men had garments of approximately their proper size. The garments worn were:

Underwear, wool, 50-50	Socks, cushion sole, 1 pair
Trousers, field, pile	Socks, ski, 2 pair
Trousers, field, cotton, OD	Shoe, felt (Alcan)
Jacket, field pile	Mukluks with burlap insoles
Parka, field, pile	Mitten, wool, trigger finger
Parka, field, cotton, OD	Mitten, shell, trigger finger

Emphasis was placed on an attempt to evaluate the degrees of comfort or discomfort experienced by men quietly seated for three (3) hours in an environment of -10°F to -14°F . On half the men of each group, for two (2) of the three (3) days of test, skin temperatures were measured at about fifteen (15) minute intervals, and on one man of each group continuous oxygen consumption data were collected for the entire three (3) hour period.

b. Sensory reactions to cold. The sensations perceived by clothed subjects in the cold are as follows*:

1. (a) The initial sensation of coolness, i.e., the change from the sensation of comfort--which might be called no sensation at all--to an awareness that coolness has supervened. This sensation is not distressing anywhere on the body. It can be the more accurately reported inasmuch as it need not be quantitated. Within the limits of accuracy demanded by the reporting procedure, no doubt exists as to the reliability of such data even though they be subjective.

(b) The intensification of the sense of coolness, which is noted as the state of being chilly or cold. On the hands and feet, this situation is no more disagreeable than that of being cool. Dexterity and tactile functions are easily restored if lost. It is never the cause for the subject's wishing he were elsewhere than where he is. However, on other parts of the body, on the legs, thighs, seat, chest, back, and neck chilliness or coldness are distinctly unpleasant and their recognition in consciousness seems to be very closely related in point of time with the onset of shivering. The distinction between coolness and chilliness requires a judgment concerning degree of intensity on the part of the subject. Inasmuch as this type of judgment is based on personal conditioning and on the special meaning of the words to the individual, it cannot be relied upon to have the same significance from time to time or from man to man.

2. (a) Shivering is not a sensation of the same order as coldness. The two may be confused and unless properly advised, a subject may state that he is cold when he means that he is shivering, and actually perceives little or no sensation of cold at such time. In other words, shivering is a motor response to cold exposure. It consists of repeated involuntary activity of small or large groups of skeletal muscle fibers associated with pilomotor activity, a tendency toward a general increase in muscle tone as opposed to relaxation, and an effort to shrink the body into a smaller area, as manifested, for example, by the head being pulled down and the shoulders brought up and forward. Since shivering, as a body response to a cold environment, is usually involuntary, it can be regarded by consciousness with some degree of objectivity. It is true that some individuals by voluntarily relaxing their muscular tenseness, are able to discontinue shivering, but

* In many reports, cold has been used indiscriminately to describe both body sensations and drop in body temperature. This perhaps derives from the supposition that the sensation of cold bears a more or less precise relationship to body temperature, to the extent that changes in the state of comfort are regarded as a protective device for the maintenance of the homeothermic state. Such thinking leads to the inference that body temperature change constitutes a direct and complete measure of the comfort value of clothing. The limitations of this approach are evident from the data here presented. Accordingly, in the present discussion comfort sensations and body temperature changes are regarded as separate phenomena in the studies of cold weather clothing. The word cold is reserved to indicate changes in the state of comfort and cooling is used to describe changes in body temperature.

they are rarely able to do this for more than twenty (20) minutes. Continued for any length of time, shivering is a distressing experience, fatiguing, and distracting. Concentration is difficult, fine muscular control is impossible, and only one thought dominates the consciousness--the desire for termination of shivering, preferably with external heat, but by means of vigorous activity if external heat is unavailable. Shivering is a phenomenon affecting nearly all parts of the body except the hands and feet, although digital function may be interfered with by tremors of the arm.

(b) The experience in the distal extremities, corresponding to shivering of the torso, is the sensation of stinging or pain--often appreciated only in the tips of the fingers or toes. The correspondence lies in the probability that these, too, are not primary sense data, but are sensations of changes taking place within the body, secondary to the primary stimulus. Pain and stinging seem to be of a different order of sensation than coldness, rather than an increased intensity of it. They interfere with functional dexterity, accurate muscle coordination, and psychological drive. The desire for escape from them frequently takes precedence over other obligations. The onset of stinging and pain in the digits can be more accurately reported than the increase of the intensity of cold sensations, as is the case with shivering of the torso. Like shivering, when stinging or pain appear, the sensation of coldness disappears.

The justification for regarding the origins of stinging and pain of the digits as physiologically similar rests on somewhat insecure ground. They do not always appear in the same order, but it is uncommon for stinging to be present without pain developing shortly afterward. To indicate their relationship, in point of time, the following analysis of their occurrence in the toes of subjects who experienced these sensations during ninety-nine (99) man-exposures of 3 hours duration to temperatures of -10° to -14°F is presented below. (Neither pain nor stinging occurred in seventeen (17) man-exposures.)

Order of Occurrence in the Toes of Stinging and Pain

<u>Event</u>	<u>No. Cases</u>
Pain without stinging at any time	40
Pain appearing before stinging, both present	13
Pain and stinging occurring simultaneously	6
Stinging appearing before pain, both present	31
Stinging without pain at any time	9
Total	99

3. The third order of sensation consists of further intensification of the experiences of shivering and pain. The order of events in the digits is usually a gradual increase in severity of the pain, sometimes associated with stinging, until numbness supervenes. However, the numbness need not be persistent, and sensation may return again. The sensation of pain itself is

not always progressive, but may be regressive, and pain may be replaced by comfort. Shivering, of course, may also change in intensity. The appreciation of the intensity of these sensations differs from time to time and from man to man. As such they are of documentary interest, but hardly useful for accurate reporting.

From the foregoing, it is not to be inferred that the awareness of initial cooling and of pain or shivering always follow the same order, or bear constant time relationships to each other. It seems to be possible for a few resistant men to experience early a sensation of cold, but to have extremity pain or shivering either late or not at all. Conversely, a few of the most susceptible men do not experience initial coldness as early as some less susceptible. In a similar manner, the development of the extremely intense symptoms of severe pain and numbness do not follow in the same order as the onset of either cooling or of pain or stinging in the extremities. However, there is no question that these manifestations of distress are phenomena which affect only the more susceptible individuals. A few subjects experience intense symptoms soon after pain appears, while others although experiencing pain, do not, during the duration of a test, become aware of an augmentation in its intensity.

On the basis of the most constant and precisely reportable of these sensations, the awareness of the onset of pain or stinging in the fingers and/or toes, and of the onset of shivering, fifty-six (56) of the white subjects may be compared. It was found possible to separate the subjects into three (3) groups, as resistant, susceptible, or intermediate reactors to cold.

The basis for classification was as follows: Shivering, pain and/or stinging in the hands, and pain and/or stinging in the feet were considered the three (3) manifestations of marked discomfort for the three (3) areas, torso, hands and feet. The hands were considered separately from the feet because they appear to cool at very different rates. Since there were three (3) days of test for each subject, a total of nine (9) sets of responses were obtained for each man: three (3) for each of the three (3) areas. If the manifestations of discomfort mentioned appeared in six (6) of the nine (9) records before two (2) hours of exposure had elapsed, the subject was classed as susceptible, provided he showed no exceptional resistance in any one of the modalities on all three (3) days. For example, an individual whose hands and feet manifested the symptoms of pain and/or stinging in less than two (2) hours every day, but who did not shiver until late in any test period, or not at all, would have the requisite six (6) responses for classifying him as susceptible, yet because of his capacity to avoid shivering, he would not be so classed. He would be placed in the intermediate category instead, because in that one modality he is actually resistant.

Subjects were classed as resistant if they experienced no discomfort whatever as above described for at least four (4) of the nine (9) possible responses, provided that of the remaining five (5), pain, stinging, or shivering were experienced in no more than two (2) in less than two (2)

hours. For example, a subject would be classed as resistant if he experienced no pain or stinging in either his hands or feet at any time, but shivered no more than two (2) of the three (3) days before two (2) hours had elapsed. The remainder of the subjects was designated as the intermediate group. Inspection of charts 1 and 2 makes this somewhat clearer. Time is indicated in quarter hour periods because it is believed that the data are no more precise than this; but significance can be attached to the finding that at one quarter hour interval pain is not perceived, while in the next it is.

It will be noted that the resistant group is one in which by and large, the distressing effects of cold are not experienced within three (3) hours. It appears possible for these subjects to remain placidly seated for an unknown time longer than three (3) hours with only minor discomfort. Contrasted with these, the susceptible subjects become miserable early in their exposures and become progressively worse with time. The classification is admittedly arbitrary. Recognition is given to the fact that men's responses are not always consistent from day to day.

Charts 1 and 2 indicate the time of onset of the distressing symptoms that result from exposure to cold under the conditions of test, of the most resistant men and the most susceptible men of the group of fifty-six (56) white men tested, for all three (3) days. It will be noted that nineteen (19) of the fifty-six (56) men may be considered susceptible in that their distressing symptoms appeared in two (2) hours or less of exposure, and that in very rare instances was any of these subjects able to go the entire three (3) hours of the test period without the occurrence of one of these symptoms. By contrast, twelve (12) of the men may be called resistant to the extent that all of them tended to be free of these distressing effects of exposure for all or the greater part of the test period. Some of them experienced no pain or stinging in their hands or feet at any time, while others did not shiver at any time; and if such symptoms did appear in this group, they did so toward the end of the test period. With the classification of nineteen (19) men as susceptible and twelve (12) men as resistant, there are left twenty-five (25) men who may be called intermediate. As would be expected, some of these closely approach the characteristics of the resistant group while others approach the susceptible. Indeed, within all the groups, the range is fairly wide, from quite susceptible to only moderately so, and from quite resistant to a lesser degree of resistance. The frequency histogram is shown in Chart 3.

In addition to the fifty-six (56) white men examined in the cold room nineteen (19) colored troops were examined in an exactly similar manner, wearing the same arctic outfits and exposed to cold room temperatures of the same level.

Among this group, the spread of reaction patterns was in general the same as among the white men, in that there were resistant and susceptible as well as intermediate reactors. The impression was gained, however, that one of the colored subjects was more resistant while others were more extremely susceptible than any of the white men tested. The resistant man had the facial characteristics and color of a full-blooded negro. The test period was shortened by about a half hour for the colored troops because the more

susceptible individuals among them complained much more bitterly of their pain and shivering than any of the white subjects. The resistant and susceptible colored subjects are compared in Chart 4.

To indicate in another way the wide range of human behavior toward cold, a system of scoring resistance has been employed. This was done by assigning arbitrary numerical values to symptom intensities, and from the total of these deriving an index number for each man's responsiveness to cold. The data for the extremities were computed separately from those of the torso, because inspection of the data suggested that the behavior of the two areas differed. No system of weighting could be found which seemed to combine the two in a manner that would satisfy even the loosest standards. The calculation is based on the number of minutes during which any particular sensation was experienced by a subject for all three (3) days. If, for example, in a three (3) hour sitting period a man cooled in 30 minutes, he would have symptoms for 150 minutes. The greater the number of minutes therefore, the lower the resistance in the scoring system.

For the feet and hands it was recognized empirically that coolness, chilliness, or coldness were not distressing as detailed above, and they were given a weight of 1. Stinging and/or pain were given a weight of 2. The system of weighting and the calculation of the index for the extremities follows:

	<u>Weighting Factor</u>
Number of minutes feet and/or hands cool, chilly or cold	x1 = a
Number of minutes feet and/or hands stinging or mildly painful	x2 = b
Number of minutes feet and/or hands stinging and/or paining severely	x3 = c
Number of minutes feet and/or hands numb	x4 = d

$$\frac{a + b + c + d}{100} = \text{Index number for extremities.}$$

For the torso, it was decided that although the sensation of coolness, as distinct from comfort, is not in any sense distressing, that of chilliness or coldness anywhere about the trunk is distinctly unpleasant. These sensations were therefore weighted differently.

	<u>Weightin Factor</u>
Number of minutes torso cool	x1 = a
Number of minutes torso chilly or cold	x2 = b
Number of minutes of moderate shivering	x3 = c
Number of minutes of intense shivering	x4 = d

$$\frac{a + b + c + d}{100} = \text{Index number for torso.}$$

On the basis of these indices, admittedly crude, some idea may be obtained of the spread of comfort experience in the cold, in a group of young men. Chart 5 gives their distribution for the extremities and for the torso respectively. It will be noted that quite a large number of men failed to have any appreciably uncomfortable symptoms about their torsos; this might be expected from the infrequency of shivering among the resistant men. For those who did have symptoms, their distribution follows somewhat the normal expectancy. The lower the final comfort index score, the more resistant the man.

APPENDIX 2

COMPARISON OF TEMPERATURE DATA WITH SENSORY EXPERIENCE.

The simultaneously recorded temperature data on the same subjects whose sensory experience has been studied, emphasizes the important point that total temperature drop of either the surface or the interior of the body is not related to the sensations perceived. This is illustrated by the individual protocols of a resistant and susceptible subject, and by the average data of the entire group of resistant and susceptible men.

The following are the protocols of two men, one resistant, the other susceptible. It is noted that they behaved quite differently in their relative degrees of comfort in the cold, distressing symptoms appearing much sooner in the susceptible man; but the subject who was subjectively the more susceptible actually had higher surface temperatures than the resistant man at the end of three (3) hours of exposure. Their rectal temperatures on the other hand were much alike.

AWARENESS OF SHIVERING

Name	Time of Onset after Exposure to Cold (Hrs.)	Avg. Body Surface Temp. at Time of Onset (°C)	Avg. Body Surface Temp. After 3 hrs. Exposure (°C)	Rectal Temp. after 3 hrs. of Exposure (°C)
Elliott				
(Resistant) 1st test	2½	24.5	24.1	36.73
2nd test	> 3	--	25.1	36.61
Terry				
(Susceptible) 1st test	1¼	28.4	26.8	36.50
2nd test	1	28.6	25.4	26.73

AWARENESS OF STINGING OR PAIN IN TOES

Name	Time of Onset After Exposure to Cold (Hrs.)	Toe Temp. at Time of Onset (°C)	Toe Temp. After 3 Hours Exposure (°C)
Elliott			
(Resistant) 1st test	> 3	--	5.4
2nd test	2-3/4	3.9	2.6

Terry

(Susceptible) 1st test	1-3/4	9.0	7.7
2nd test	1-1/2	14.1	8.4

The dissimilarity of sensory experience in the cold between the resistant and susceptible subjects is no better reflected in the average temperatures of the entire group of subjects than it is in the records of the two men just presented. Chart 6 shows the average rectal temperatures of the resistant, susceptible, and intermediate subjects for three (3) successive exposures in the cold room. The similarity in the temperatures is in striking contrast to the differences in the comfort of the men.

Chart 7 shows the average surface temperatures of the same groups for two (2) successive exposures. Again there is no relation between the temperatures and the differences in sensory experience.

In Chart 8 the average temperatures of each of the several areas measured are presented for two (2) successive exposures in the cold. It is clear from these charts that the sensory perception of disagreeable symptoms of cold bears little relationship to body temperature after a standard period of exposure.

It would be desirable to know whether there is any temperature of the toes at which pain is perceived by a majority of subjects exposed to the cold, or whether there is a time-temperature factor involved in the perception of toe pain. Chart 9 indicates that pain in the toes is first appreciated by different men at temperatures ranging from 0.1°C to 15.2°C. The median toe temperature at the onset of pain was 7°C for the entire group and 50% were found to be within 5° and 9°C. There appears, however, to be no significant difference in the distribution for the three (3) groups. The time of onset of pain after the beginning of exposure to the cold is neither constant, nor does it correspond with the toe temperature at that time. Indeed seven (7) subjects were not aware of pain in their toes at any time despite the fact that at the end of three (3) hours of exposure their toe temperatures ranged from 2.4 to 10.4°C.

Chart 10 presents the relationship between subjective perception of shivering and average body surface temperature.* It is apparent that susceptible men shiver early in spite of the fact that the body surface temperature has not dropped substantially. A number of subjects failed to become aware of shivering during their entire exposure period.

* Average skin temperatures were computed using the following weighting system: Chest - .30; hip - .30; arm - .16; thigh - .18; and toe - .06.

APPENDIX 3

STUDY OF ATTRIBUTES OF SUBJECTS WHICH MIGHT BE RELATED TO COMFORT IN THE COLD.

One objective of the study was to identify those attributes of the subjects, other than temperature change, which might be correlated with their degree of susceptibility to cold. Accordingly, a variety of observations were made which were thought pertinent to the preselection of men for cold combat theaters as well as for cold room studies. Data were collected on all subjects, but the tabular analyses which follow are for the white subjects only.

The attributes examined were:

- | | |
|---|--------------------------|
| 1. Age | 8. Body Build |
| 2. Height | 9. Color of Hair |
| 3. Weight | 10. Depth of Skin Color |
| 4. Weight/Height | 11. History of Frostbite |
| 5. Surface Area | 12. Tendency to Sunburn |
| 6. GI Shoe size | 13. Home State |
| 7. A.G.C.T. Scores | 14. Emotional Stability |
| 15. Tendency to sweat in the palmar, solar, and axillary areas | |
| 16. Liking for cold expressed before cold room exposure | |
| 17. Response to Cold Pressor Test and Digital Plethysmography | |
| 18. Pain response upon immersion of foot in water at 5°C | |
| 19. Average number of cigarettes smoked per day | |
| 20. Sensitivity to pain of intradermal injection of 10% NaCl solution | |
| 21. Time of Onset of shivering when exposed nude in cold room at -10°F. | |

In brief, it appears that no one of the attributes examined correlates well with the degree of susceptibility of a group of men to cold. This is not to say that older men may not be more susceptible than younger because of degenerative arterial changes, nor that some men may not respond poorly to cold because of psychological deficiencies, which in turn are reflected as vasomotor effects. However, no one attribute thus far investigated seems to be applicable to groups of men, in a manner sufficiently consistent to make prediction of resistance or susceptibility possible.

It does appear from the following tabular data, that among the resistant subjects, certain characteristics are relatively uncommon. For example, only a small number of resistant men are emotionally unstable, while the susceptibles are about half stable and half unstable. It appears too that resistant subjects as a rule know in advance of their liking for cold. Only three (3) of the twelve (12) expressed a dislike for it, yet found themselves resistant. Further, only two (2) of twelve (12) resistant subjects reported

a tendency to burn when exposed to the sun, while of the susceptibles, half reported a tendency to burn and half an inclination to tan. This does not mean that one skin had a higher or lower erythema threshold than another. The assertion by a subject that he burns when exposed to the sun means that he experiences discomfort as a consequence of his exposure. It is an evaluation of a degree of well being dependent in part on the degree of tissue injury, but also is dependent on the autonomic and psychological reactions to the tissue injury. Finally, among the resistant men, nine (9) were hypo-reactors to the cold pressor test while only three (3) were hyperreactors. The susceptible men were equally divided between the two types of responses. However, when each resistant and susceptible subject's particular characteristics were examined individually, it was found that there was no consistency with regard to this apparent pattern. An over-all tabular treatment indicates no correspondence between resistance to cold and these four attributes described above; namely, tendency to sunburn, emotional stability, expressed dislike for cold, and cold pressor reaction. The distributions of all the white subjects, according to their various attributes, are given in the tables that follow.

DISTRIBUTION OF RESISTANT, SUSCEPTIBLE AND
ALL SUBJECTS, ACCORDING TO:

	<u>RESISTANT</u>	<u>SUSCEPTIBLE</u>	<u>ALL SUBJECTS</u>
<u>General Characteristics:</u>			
Average age	20.2	20.5	20.5
Average height (in.)	66.5	67.4	67.6
Average weight (lbs.)	149.6	145.8	148.8
Weight per unit height	2.24	2.17	2.19
Surface area (sq. M.)	1.77	1.77	1.79
Average G. I. shoe size	<u>7.16</u>	<u>7.89</u>	<u>8.17</u>
Total no. subjects	12	19	60
<u>Body Build:</u>			
Very slender	4	4	14
Slender	3	10	25
Average	3	4	15
Stocky	<u>2</u>	<u>1</u>	<u>5</u>
Total	12	19	59
<u>Color of Hair:</u>			
Dark	4	6	17
Medium Blond	4	3	14
Blond	3	7	23
Gray		1	1
Red		1	1
No record	<u>1</u>	<u>1</u>	<u>—</u>
Total	12	19	58
<u>Depth of Skin Color:</u>			
Dark	6	6	21
Fair	5	11	32
Very Fair	0	1	4
No record	<u>1</u>	<u>1</u>	<u>2</u>
Total	12	19	59
<u>Geographical Region of Origin:</u>			
Northern States	3	3	11
Central States	7	13	35
Southern States	1	1	7
No record	<u>1</u>	<u>2</u>	<u>3</u>
Total	12	19	56
<u>Areas Previously Frostbitten:</u>			
Ear	2	3	5
Cheek	1	0	2
Nose	0	1	3
Heel	1	0	3
Toe	0	3	6
Finger	<u>1</u>	<u>1</u>	<u>3</u>
No. of Subjects Frostbitten	4	6	16
Total Subjects	12	19	56

In every case of frostbite, a history could be obtained of a hole in a glove or shoe, of melted snow inside the shoe, or of exposure to high wind in cases of facial freezing. Only two of these subjects had the impression that the frostbitten areas had a greater tendency to get cold on that account.

A.G.C.T. Score Groups:

	<u>RESISTANT</u>	<u>SUSCEPTIBLE</u>	<u>ALL SUBJECTS</u>
I	0	1	3
II	3	0	5
III	2	6	15
IV	3	3	14
V	<u>1</u>	<u>0</u>	<u>1</u>
Total	9	10	38

DISTRIBUTION OF RESISTANT, SUSCEPTIBLE AND
ALL SUBJECTS, ACCORDING TO ESTIMATES
OF:

	<u>RESISTANT</u>	<u>SUSCEPTIBLE</u>	<u>ALL SUBJECTS</u>
<u>Sweating Tendency of Palms, Soles, and Axillae when not Overheated:</u>			
Little	5	6	21
Moderate	7	11	35
Profuse	0	1	2
No Record	<u>0</u>	<u>1</u>	<u>1</u>
Total	12	19	59

Tendency to Sunburn:

Tan	9	9	32
Burn	2	10	26
No Record	<u>1</u>	<u>0</u>	<u>1</u>
Total	12	19	59

Reaction to Cold:

Do not dislike it	9	10	35
Do dislike it	3	<u>2</u>	<u>22</u>
Total	12	19	57

This last query was made because it seemed reasonable that the best way to determine whether a man remains comfortable in the cold is to ask him. It turns out, however, that many men don't know, either because they have never been exposed enough, or because they have been exposed too much while wearing too little or improper clothing. Moreover, if a man has had one especially unpleasant experience, he tends to remember it to the exclusion of others that were less striking. The group listed above as not disliking the cold actually reported either that they liked it, were accustomed to it, or were indifferent. The group who did dislike it invariably said just that.

DISTRIBUTION OF RESISTANT, SUSCEPTIBLE AND
ALL SUBJECTS ON THE BASIS OF SPECIFIC
TESTS

RESISTANT SUSCEPTIBLE ALL SUBJECTS

Cold Pressor - 1st Test:

Hyper-reactors	3	9	27	
Hypo-reactors	2	<u>10</u>	<u>29</u>	
Total	12	19	56	

All subjects reclined eight (8) to ten (10) minutes, after which control pressures were taken until two which checked were obtained. The hand was then immersed in ice water, and blood pressure readings were made at one-half ($\frac{1}{2}$) and one (1) minute thereafter. The higher readings were selected. Hyper-reactors were said to be those who had systolic pressure elevations of 20 mm, and diastolic of 15 mm above control levels.

Cold Pressor - 2nd Test:

Hyper-reactors	2	4	10	
Hypo-reactors	<u>2</u>	<u>2</u>	<u>6</u>	
Total	4	6	16	

This was a repeat test on sixteen (16) of the subjects previously examined. It differed from the first in that the subjects reclined for at least fifteen (15) minutes before the test was administered, and blood pressure readings were made at one (1) and two (2) minutes after the hand was immersed in ice water.

Time Elapsing Before Perception of Pain Upon Immersing
Distal Third of Foot in Water at 5°C

Less than 30 sec.	7	9	24	
31 to 60 sec.	2	9	22	
61 to 90 sec.	1	0	2	
More than 90 sec.	0	1	6	
No pain perceived	<u>2</u>	<u>0</u>	<u>2</u>	
Total	12	19	56	

"Adaptation" Time to the Pain Resultant
from Immersing Distal Third of Foot in Water at 5°C

Less than 60 Sec.	0	1	6	
61 to 120 Sec.	4	5	15	
121 to 180 Sec.	3	3	10	
181 to 240 Sec.	2	6	11	
241 to 300 Sec.	0	2	6	
More than 300 Sec.	1	2	6	
No pain perceived	<u>2</u>	<u>0</u>	<u>2</u>	
Total	12	19	56	

These two tests were performed by having the subject lie prone on a couch, while dipping the distal third of his foot in constantly stirred water at 5°C. The subjects were instructed to ignore the sensation of cold, and to report only the onset, augmentation, diminution, and disappearance of the deep aching pain, which is a characteristic response to this type of stimulus. The time of the first, and the difference in time between the first and last of these are given in the tables.

Time of Onset of Shivering Upon Exposure
Nude in the Cold Room at -10°F

<u>1st Exposure</u>	<u>RESISTANT</u>	<u>SUSCEPTIBLE</u>	<u>ALL SUBJECTS</u>
Less than 60 sec.	6	7	20
61 to 120 sec.	1	4	10
121 to 180 sec.	0	3	7
More than 180 sec.	3	1	7
No Shivering	<u>2</u>	<u>4</u>	<u>12</u>
Total	12	19	56

2nd Exposure

Less than 60 Sec.	5	9	25
61 to 120 Sec.	1	3	10
121 to 180 Sec.	0	1	1
More than 180 Sec.	1	4	6
No Shivering	<u>2</u>	<u>2</u>	<u>14</u>
Total	12	19	56

For this test, two subjects at a time were taken into the cold room nude on the afternoons of their first and third days at the laboratory, from one (1) to two (2) hours after the noon meal. They stood on a paper covered wood platform raised approximately two (2) inches off the concrete floor. The onset of shivering was recorded as the first evidence of involuntary muscle quivering.

OTHER OBSERVATIONS:

A gross evaluation of the inclination toward neurotic behavior was made following interviews with the subjects, in which questions were asked concerning the occurrence of palpitation, dizziness, headache, digestive disturbance, specific fears, and reactions to various types of stress. Only one subject seemed to be patently abnormal with symptoms strongly suggestive of the effort syndrome. He turned out to be a susceptible subject, but not as intensely so as some others who were considered emotionally stable. The distribution of the men was as follows:

Psychoneurotic Tendency:

Stable	9	9	34
Unstable	<u>2</u>	<u>10</u>	<u>22</u>
Total	12	19	56

To check the observations in this aspect of the study, Captain M. B. Jensen, and M/Sgt. Rotter, psychologists at the Armored School, were asked to examine sixteen (16) of the subjects in more detail. They used for this purpose two self-rating questionnaires, and an electrodermal apparatus for measuring skin resistance of the palm. Their results are given as they submitted them.

"1. Sixteen (16) subjects were examined for initial skin resistance and skin resistance after two minutes with an electro-galvanic skin resistance apparatus. They also filled out self-rating scales dealing with overconcern with health (tendency toward hypochondriasis) and overconcern with self (psychasthenic tendency). Scores on these techniques were correlated with ratings of ability to withstand cold.

"2. Slight trends were indicated, showing the relationship between the measures and ability to withstand cold. The susceptible subjects showed a tendency towards lower initial skin resistance, greater concern with health, and a neurotic tendency. This tendency was shown in difference between means for the top eight as compared to the bottom eight, and in low correlations between rank order of rating of ability to withstand cold and rank order of score on the various psychological techniques. Neither correlations nor the difference between means could be established to be statistically reliable with the small numbers of subjects used. A correlation of 0.39 between concern over health and initial onset of shivering was the highest obtained. These trends were more significant when the original overall rankings were used, based apparently upon an immediate impression, than with the final set of ranking submitted.

"3. Results of this examination suggested that a relationship exists between the factors studied and the measures of resistance to cold used in computing the ratings made. In order to determine whether or not this tendency is statistically reliable, larger numbers of cases would have to be examined.

"4. Scores for the sixteen (16) subjects are appended."

	Ohms Initial Skin Resistance	Ohms Skin Resistance 2 Minutes	Health Inventory	Psychasthenic Inventory
<u>RESISTANT</u>				
Elliott	30,000	43,000	1	4
Rodrigues	25,000	35,000	3	10
Cantley	45,000	52,000	3	4
Fisher	20,000	28,000	13	17
<u>INTERMEDIATE</u>				
Johnson	16,000	20,000	1	3
Contreras	110,000	125,000	6	10
Turner	80,000	85,000	0	0
Woods	30,000	50,000	5	6
Wyley	18,000	36,000	1	0
Kerns	19,000	25,000	13	28
<u>SUSCEPTIBLE</u>				
Venture	30,000	48,000	5	9
Kornack	26,000	50,000	6	8
Hansen	26,000	24,000	9	9
Clark	15,000	20,000	12	14
Gleckler	54,000	70,000	8	8
Mantice	25,000	36,000	1	3

(In interpreting this table, the lower skin resistance implies a greater inclination toward neurotic behavior, while the higher scores on the health and psychasthenic inventories imply a greater tendency toward neurotic behavior--Author.)

In addition to the preceding, a number of subjects were given intracutaneous injections of 0.1 cc of 10% NaCl solution, and the time of onset and duration of deep pain were measured. There were too few subjects for the data to be significant, but it did appear that the cold resistant individuals perceived the pain later, and reported its disappearance earlier than the susceptibles. Some colored susceptible subjects were also given this test, and their responses were much like those of the susceptible white subjects. However, one of the resistant and two susceptible subjects perceived no pain whatever from the injections despite their being given in a manner identical to the others; this appears to vitiate the reliability of the test.

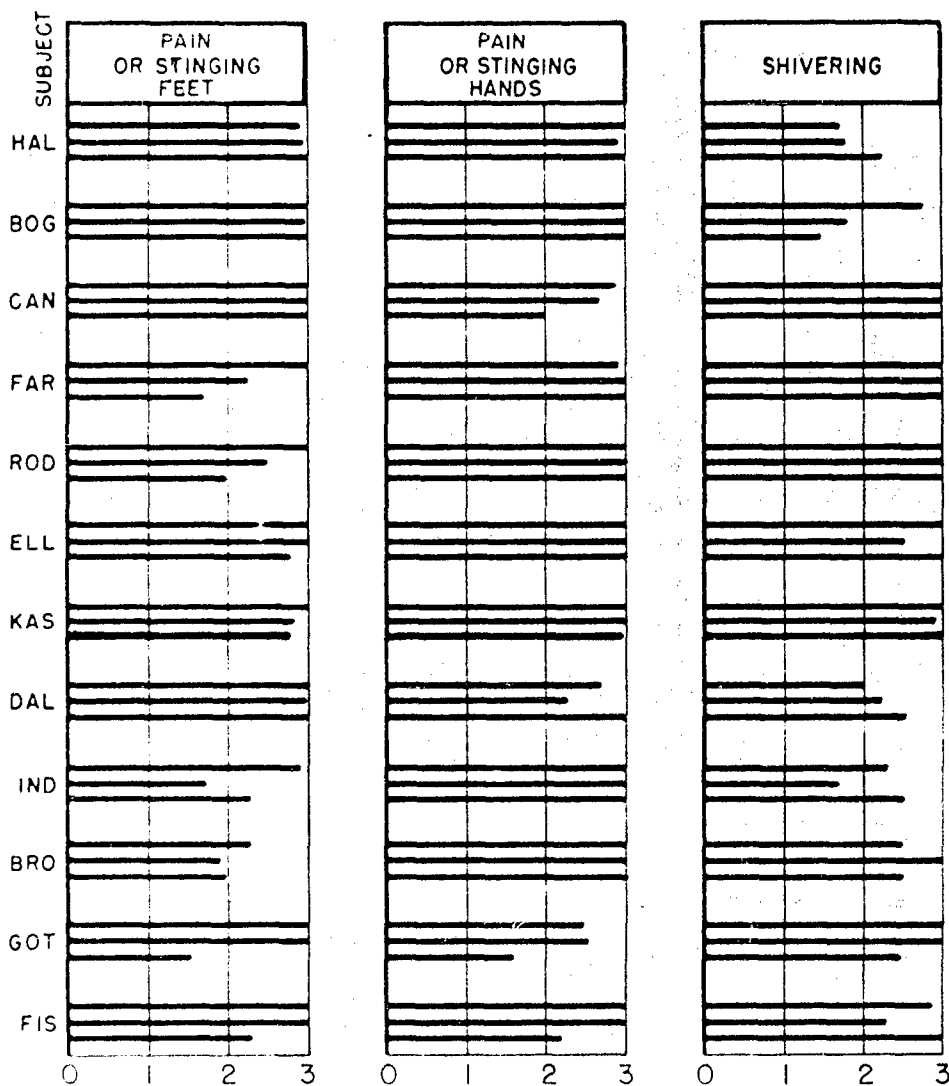
Digital plethysmography was performed by Captain L. W. Eichna on six (6) of the subjects; two (2) resistant, one (1) intermediate, and three (3) susceptible. The stimuli were: pinching, deep breath, ice applied to the neck, mental problem, loud noise, and immersion of the forearm in ice water. Review of the tracings revealed poor correspondence to cold susceptibility in that the only normal reactor of the group was a subject classed as susceptible to cold, while the two (2) men classed as resistant to cold tended to be hyper-reactors.

The number of cigarettes smoked per day was found to be on the average 14.3 for the resistant, 11.3 for the susceptible, and 11.3 for all the subjects. These figures were quite unimpressive, although before the inquiry was made, it was thought not unlikely that the heavy smokers would tolerate the cold more poorly than the light smokers or the abstainers because of known effects of smoking on peripheral blood flow in some men.

Finally, in order to determine whether the men whose feet are the least comfortable in the cold room tend to have lower toe temperatures in comfortable ambient temperatures, the following procedure was carried out. About three-quarters of any hour after the noonday meal, each subject was seated on the laboratory floor, with shoes and socks removed, and the legs outstretched, the bare heels resting on the floor. The floor temperature was about 71°F and the air temperature between 76° - 78°F. After the men had been quietly seated for half an hour, the temperatures of the dorsal and ventral surfaces of both great toes were taken with a thermopile. These four temperatures were averaged. The subjects were then listed in rank order with regard to the average degree of comfort of their feet in the cold room over the three days of exposure, and this order of rank was plotted against the average resting toe temperatures. It is seen in Chart 11, that no correlation exists, except that the three most susceptible men do have low toe temperatures; in none of these was vascular disability suspected.

CHART I

TIME OF ONSET OF SUBJECTIVE SENSATIONS OF COLD RESISTANT SUBJECTS



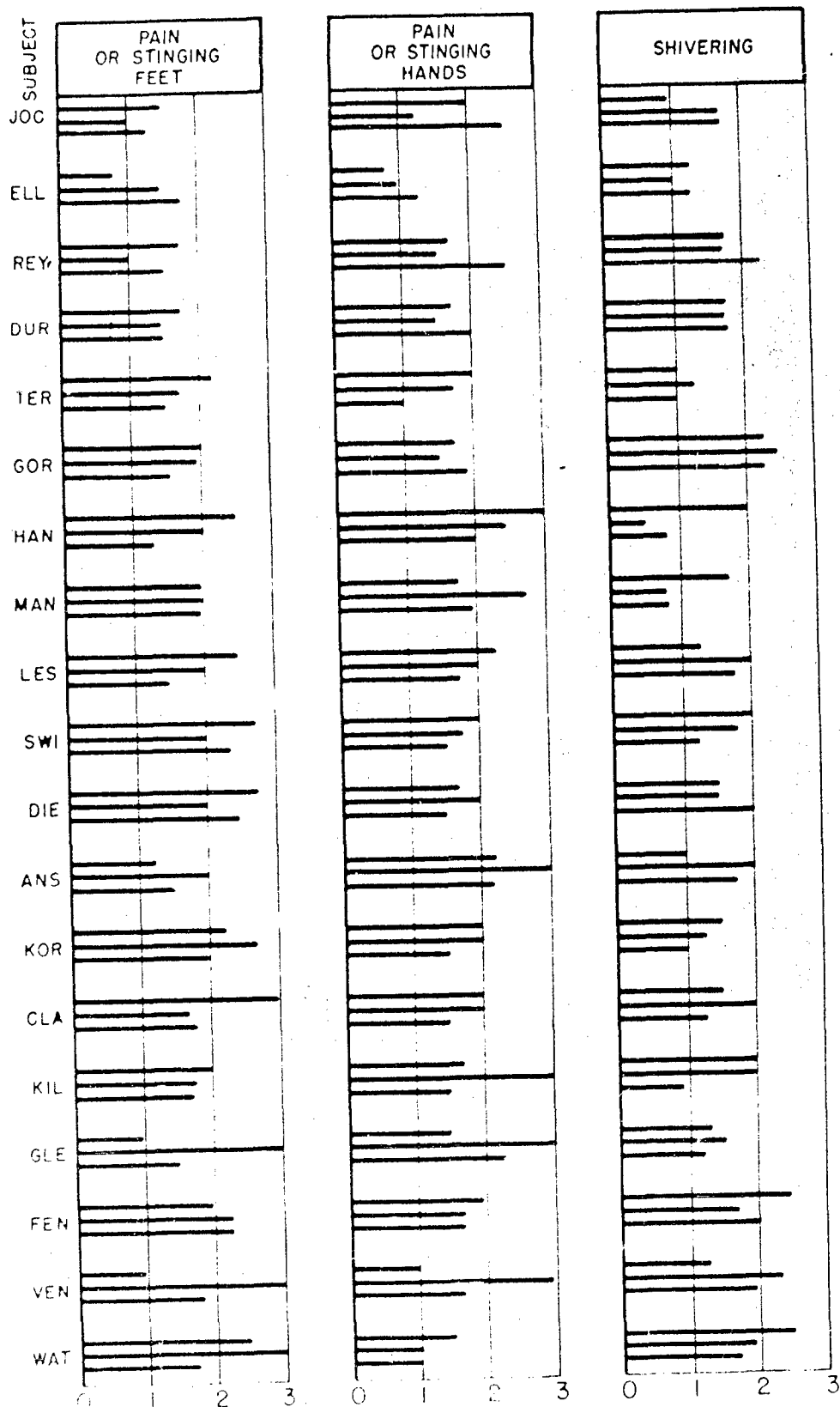
DURATION OF EXPOSURE UNTIL ONSET OF STATED SENSATION, HOURS

LINES EXTENDING THROUGH 3 HOURS INDICATE STATED SENSATION NOT OBSERVED DURING TEST EXPOSURE PERIOD

EACH SUBJECT OBSERVED ON THREE SUCCESSIVE DAYS

CHART 2

TIME OF ONSET OF SUBJECTIVE SENSATIONS OF COLD SUSCEPTIBLE SUBJECTS



DURATION OF EXPOSURE UNTIL ONSET OF STATED SENSATION, HOURS

CHART 2

CHART 3

DISTRIBUTION OF FIFTY SIX (56) WHITE SUBJECTS AS
RESISTANT, SUSCEPTIBLE, OR INTERMEDIATE
REACTORS TO COLD

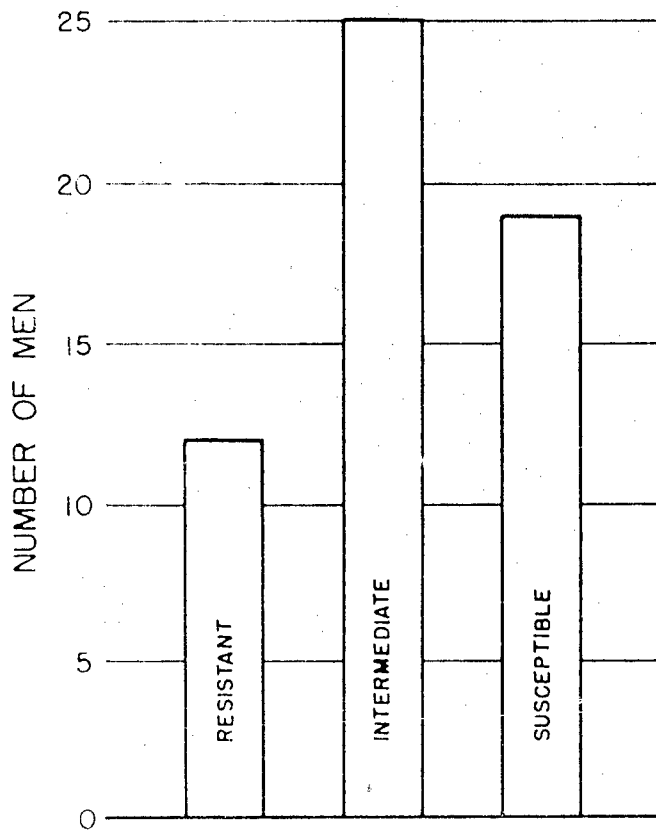
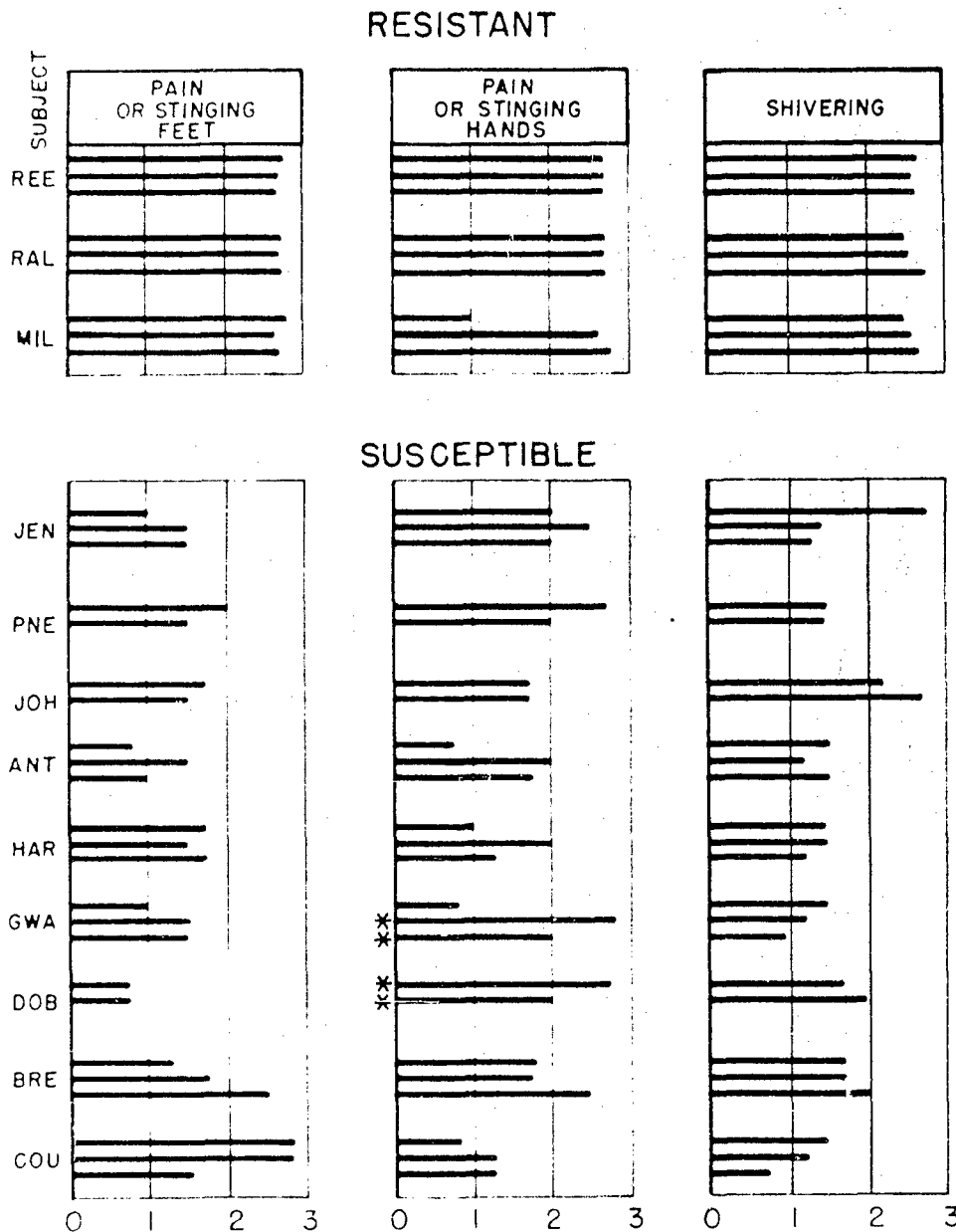


CHART 3

CHART 4

TIME OF ONSET OF SUBJECTIVE SENSATIONS OF COLD (COLORED SUBJECTS)



DURATION OF EXPOSURE UNTIL ONSET OF STATED SENSATION, HOURS

Lines extending through 2 1/2 hours indicate stated sensation not observed during test exposure period

* EXTRA PROTECTION PROVIDED IN THE FORM OF FUR GLOVES

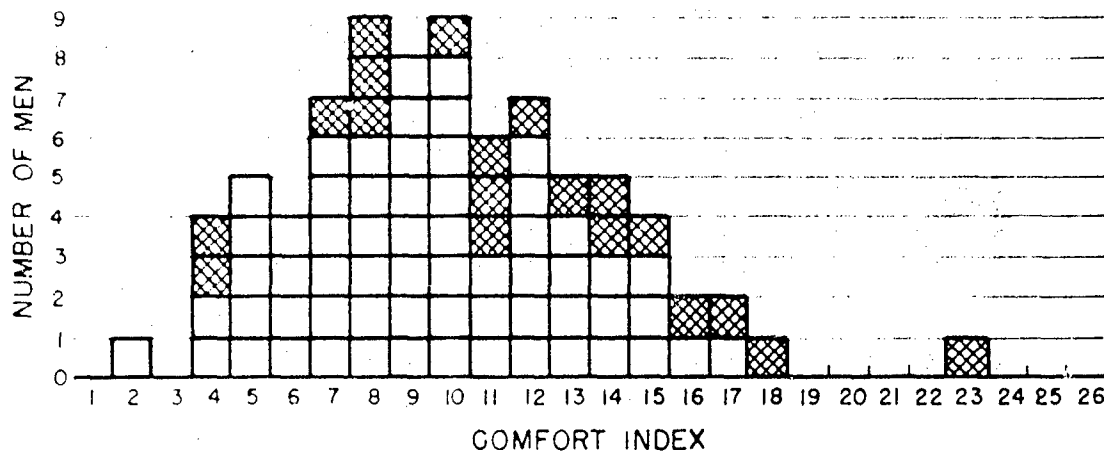
EACH SUBJECT OBSERVED ON THREE SUCCESSIVE DAYS

CHART 5

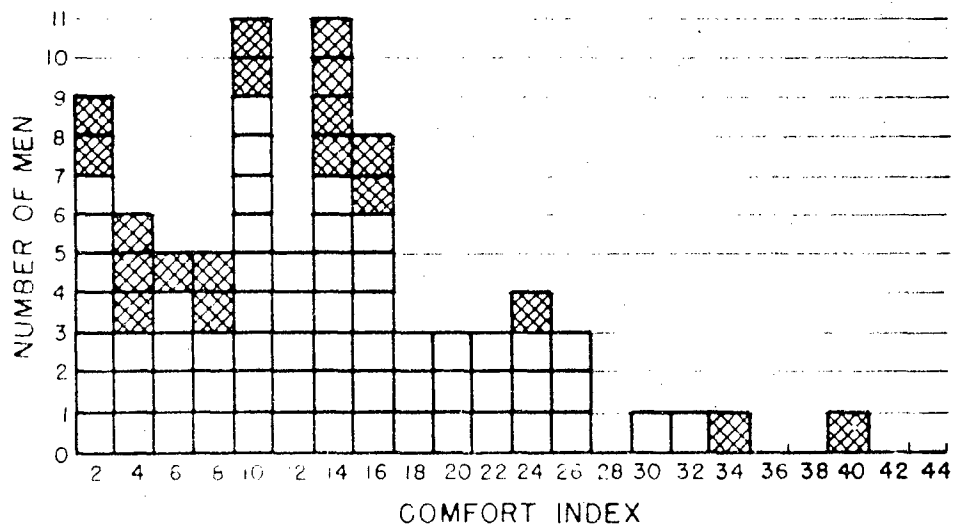
DISTRIBUTION OF 80 MEN IN RELATION TO THEIR COMFORT INDICES

LOW INDEX NUMBERS INDICATE GREATER RESISTANCE

HANDS AND FEET



TORSO AND LIMBS



☐ WHITE SUBJECTS
☒ COLORED SUBJECTS

CHART 5

CHART 6

AVERAGE RECTAL TEMPERATURES OF 56 MEN BEFORE
AND AT END OF 3 HOUR EXPOSURE TO COLD (-10° TO -14° F)

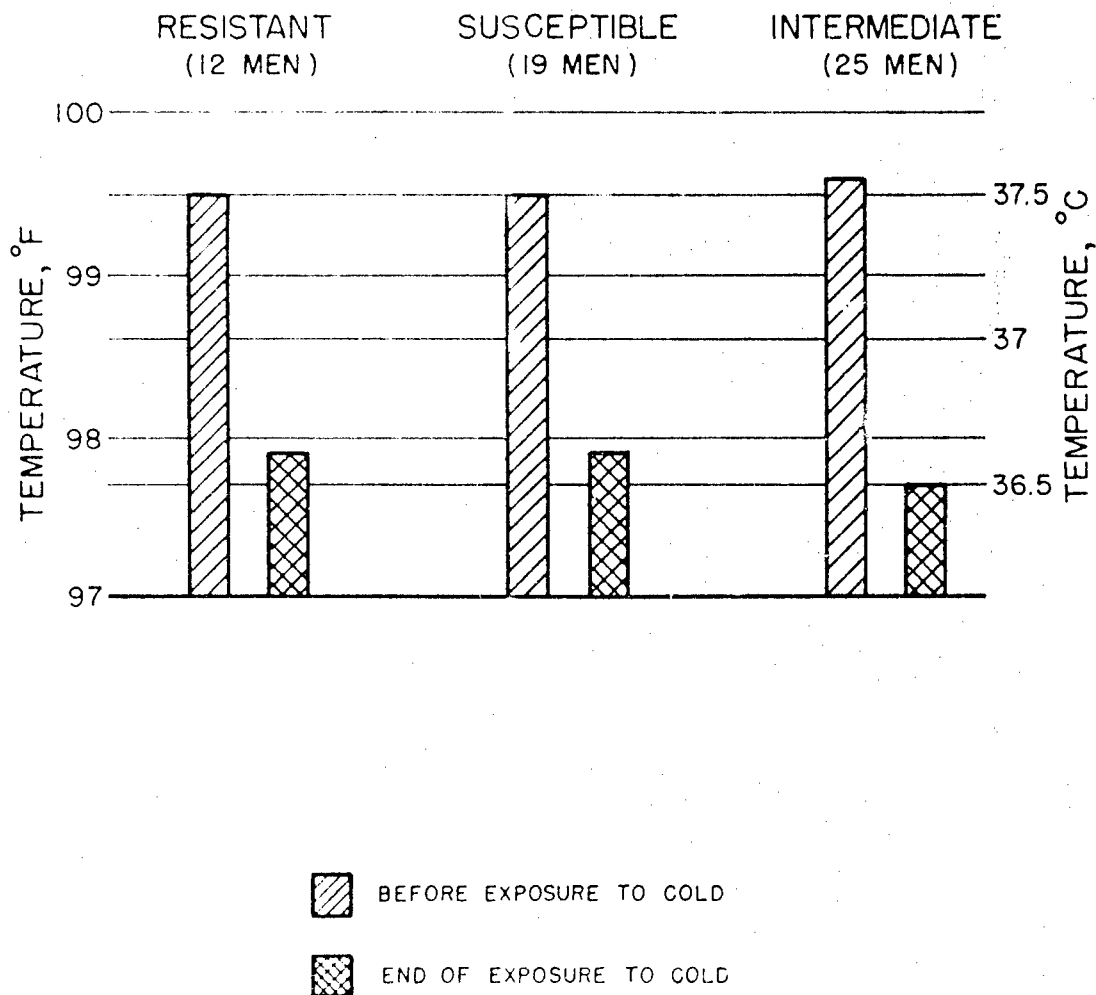


CHART 6

CHART 7

AVERAGE BODY SURFACE TEMPERATURES OF 56 MEN
BEFORE AND AT THE END OF 3 HOUR EXPOSURE TO COLD

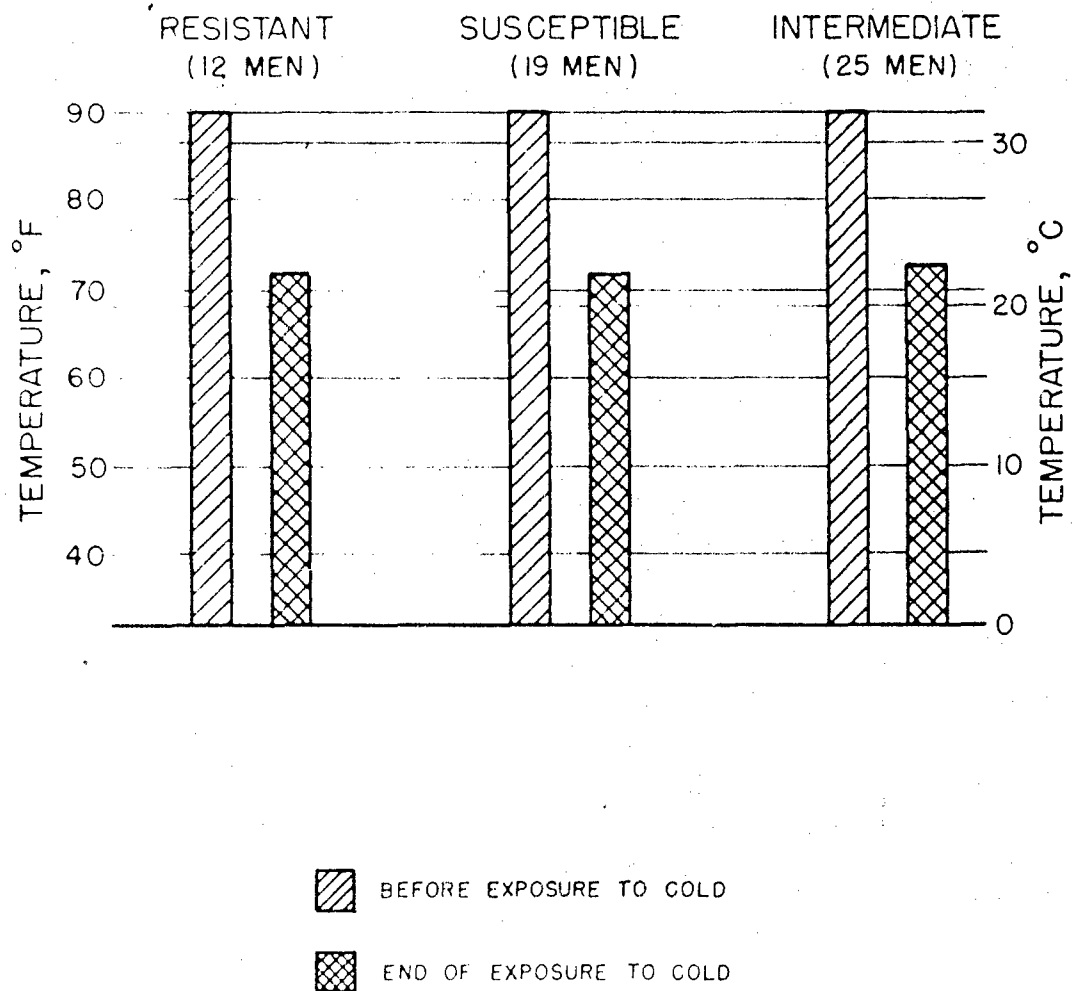


Chart 7

CHART 7

CHART 8

AVERAGE TEMPERATURES OF SEVERAL BODY AREAS OF 56 MEN BEFORE
AND AT THE END OF 3 HOUR EXPOSURE TO COLD (-10° TO -14° F)

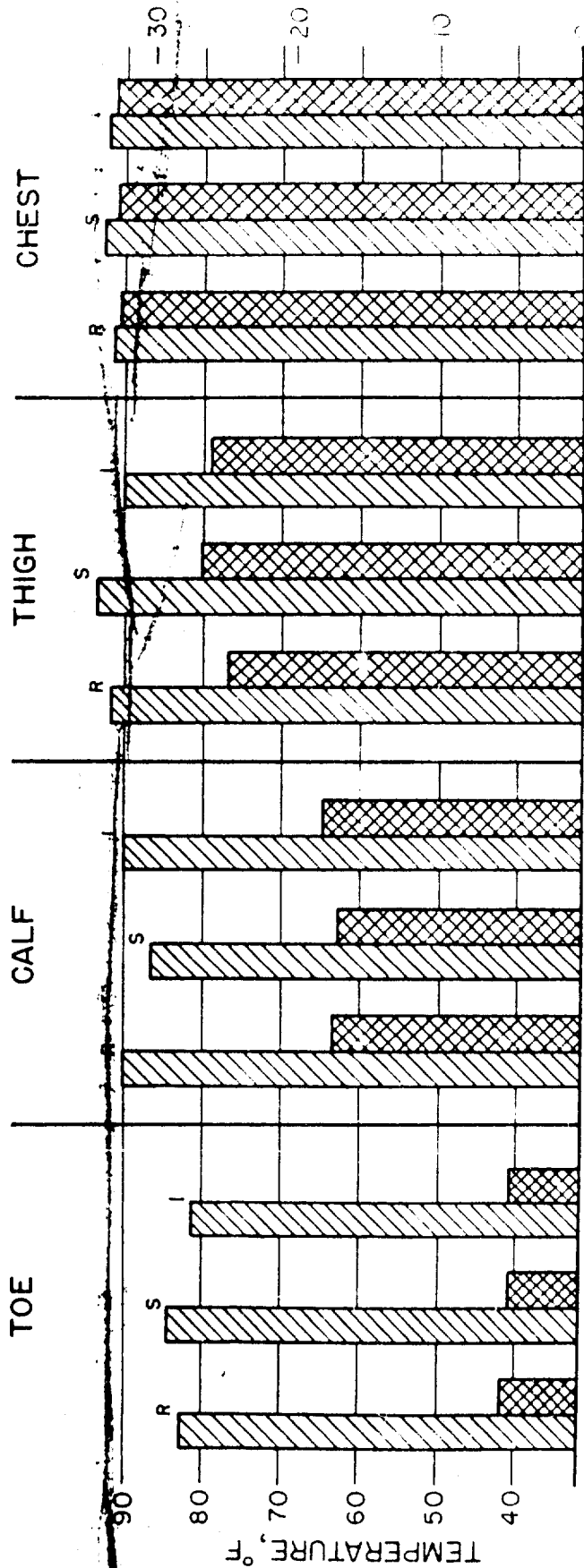


CHART 9

RELATIONSHIP BETWEEN THE TIME OF ONSET OF STINGING
OR PAIN IN THE TOES AND COINCIDENT TOE TEMPERATURE
COLD ROOM TEMPERATURE -14°F

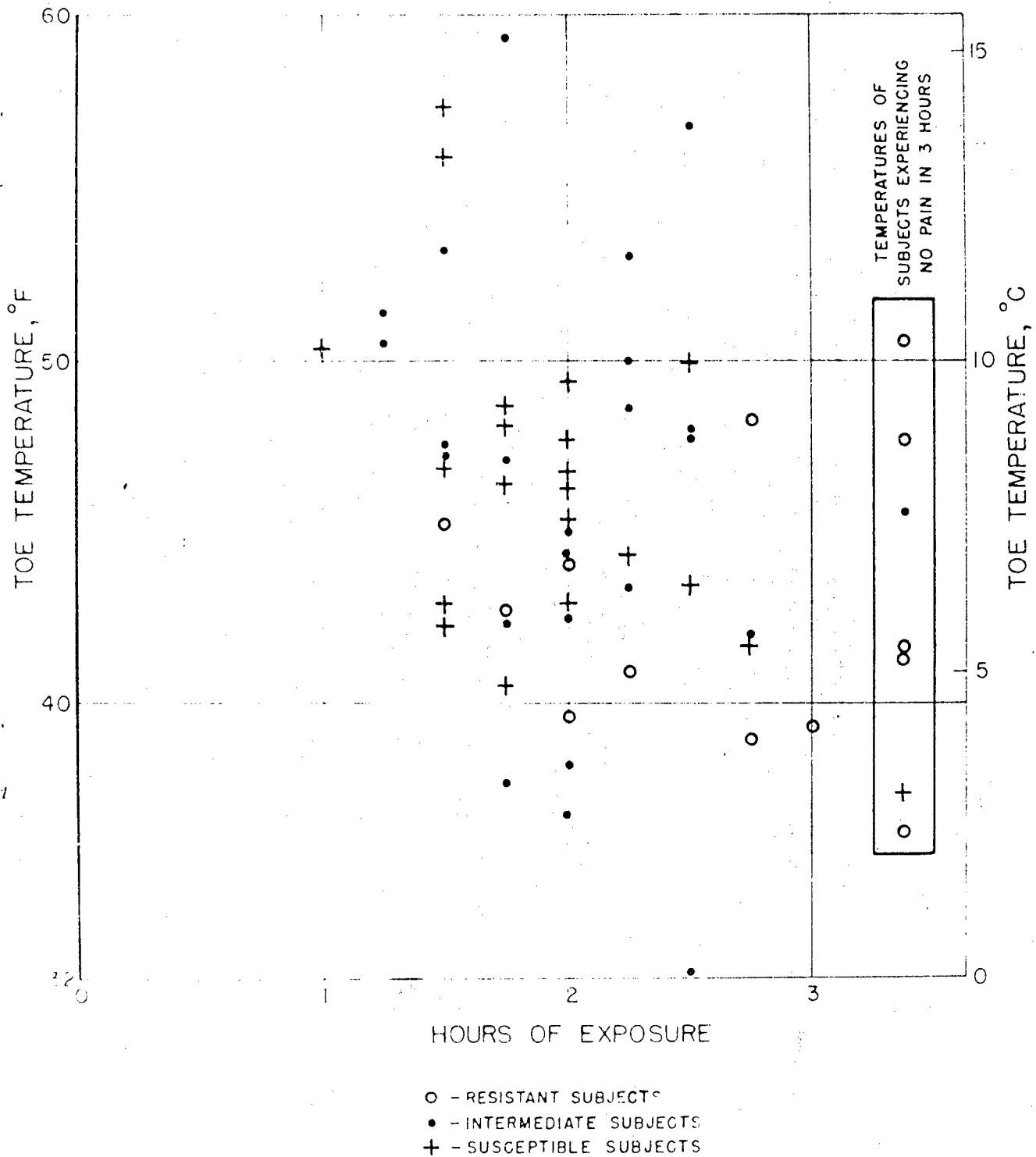


CHART 10

RELATIONSHIP BETWEEN THE TIME OF THE FIRST PERCEPTION OF SHIVERING AND COINCIDENT AVERAGE BODY SURFACE TEMPERATURE

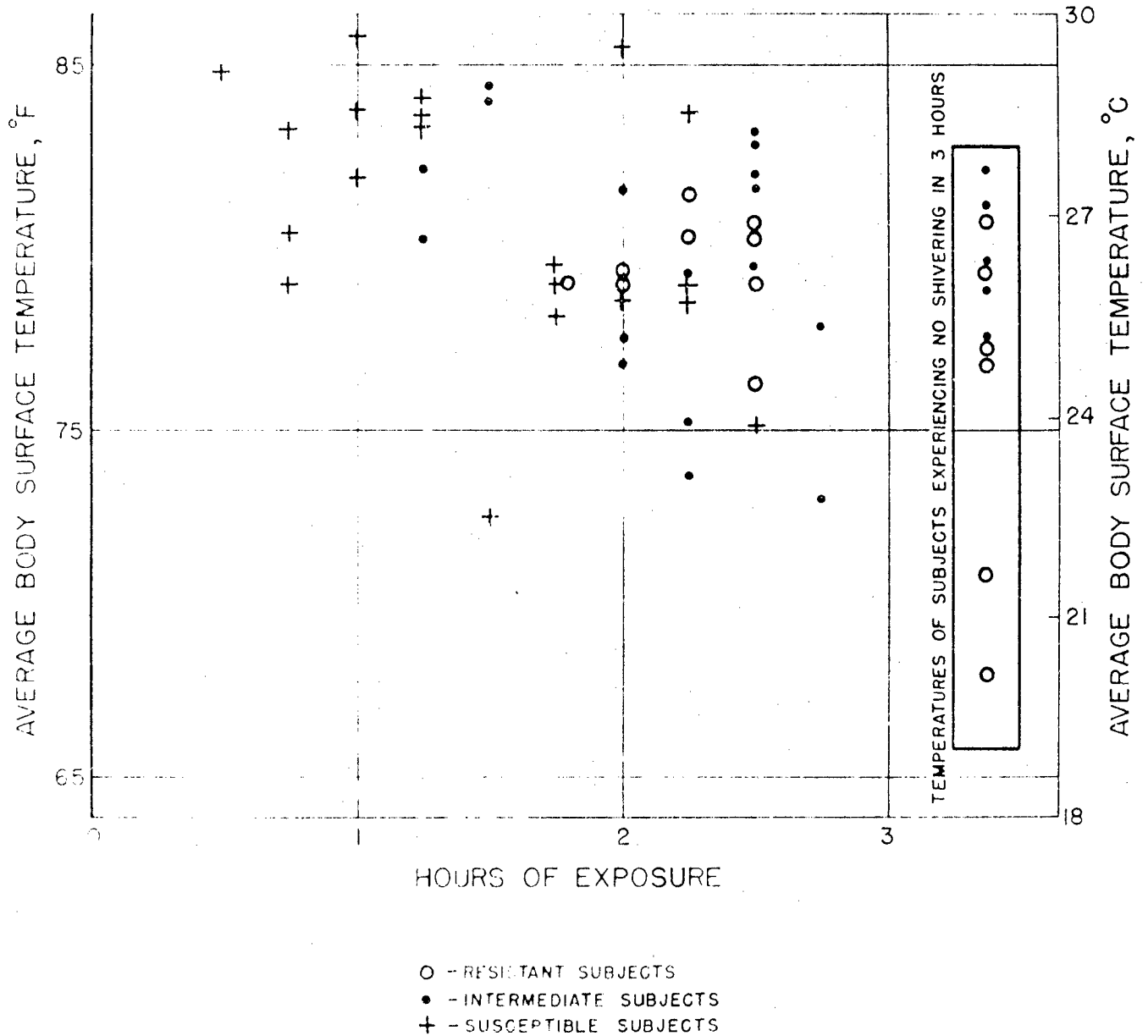


CHART II

RELATIONSHIP BETWEEN TOE TEMPERATURE AT 76° F. AMBIENT
AND SYMPTOM INTENSITY ON EXPOSURE TO COLD (-10° TO -14° F)

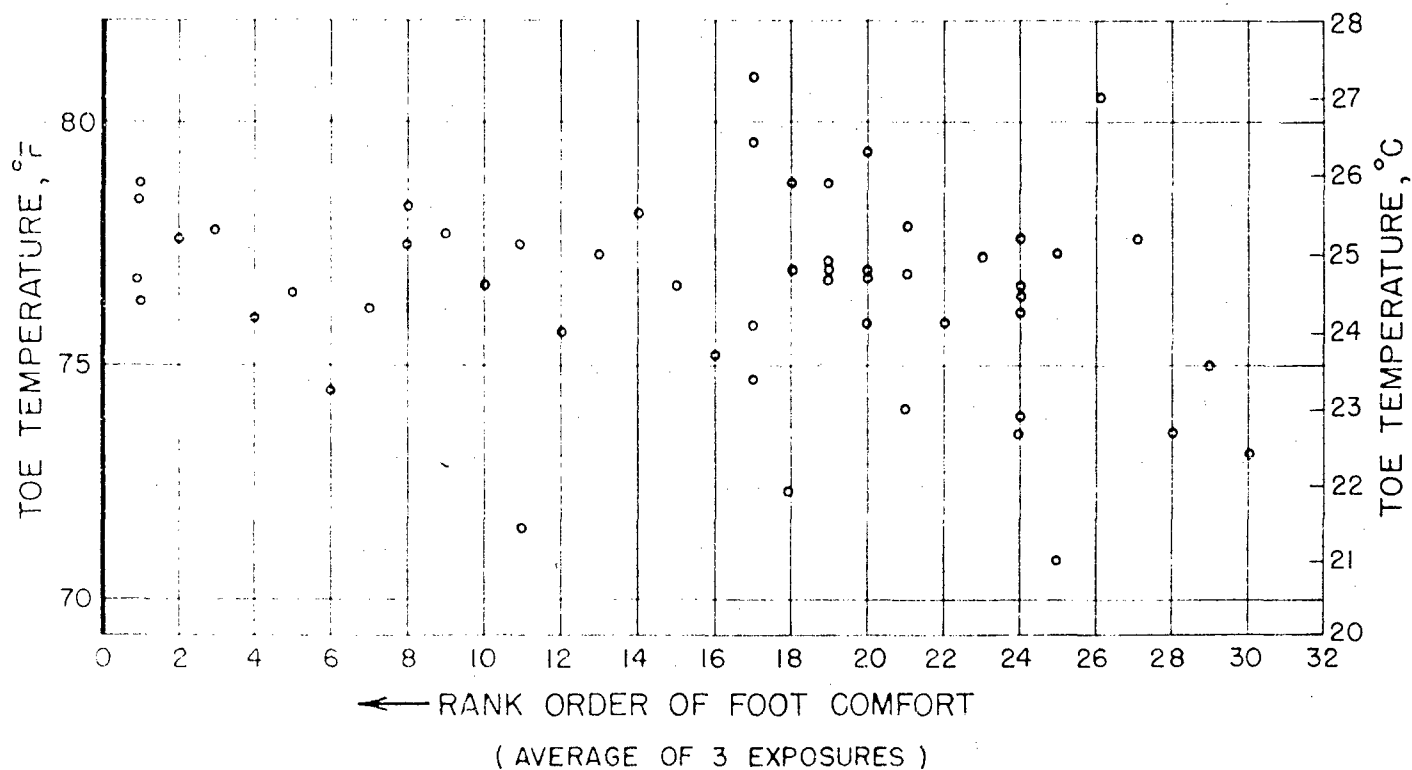


Chart II 4

CHART II

17